10 Years of Airborne Imaging Spectroscopy within EUFAR

EUFAR - European Facility for Airborne Research

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EUFAR background

- EUFAR links the operators of research aircraft and their instrumentation, instrument developers, scientific experts and users and funding agencies involved in airborne environmental research in Europe.
- EUFAR aims to enhance collaboration, spread good practice, promote efficiency and enhance user access to both the facilities and their data.
- EUFAR services:
  - Airborne measurement campaigns.
  - Common data portal.
  - Tools for data discovery and processing.
  - Calibration standards and software for airborne measurements.
  - INSPIRE-compliant metadata to aid inter-operability.

History of EUFAR

2000-2004	2004-2008	2008-2013	2014-2018
EUFAR	**EUFAR**	**EUFAR**	**EUFAR2**
FP5 Infrastructure Cooperation Network	FP6 Integrated Infrastructure Initiative	FP7 Integrated Infrastructure Initiative	FP7 Integrated Infrastructure Initiative
€640k	€5M	€8M	€6M
9 partners	22 partners	34 partners	24 partners

2000

HYRESSA

2018

2007-2011
COPAL
FP7 Preparatory Phase Study
€1M
13 partners

Early 2018
Constitution of the EUFAR AISBL

Airborne Imaging Spectroscopy in EUFAR

Until 2018 multiple hyperspectral cameras of different operators were available through EUFAR transnational access (TNA) to European researchers

- AHS and CASI
  Operator: INTA (Spain)
- aisaFenix and aisaOwl
  Operator: NERC ARSF (UK)
- Airborne Prism Experiment (APEX)
  Operator: VITO (Belgium) & UZH (Switzerland)
- HySpex
  Operator: DLR (Germany)
- TASI and HySpex
  Operator: CNR (Italy)
- CASI and HySpex
  Operator: FUB (Germany)
- CASI, SASI, TASI
  Operator: CzechGlobe (Czech Republic)

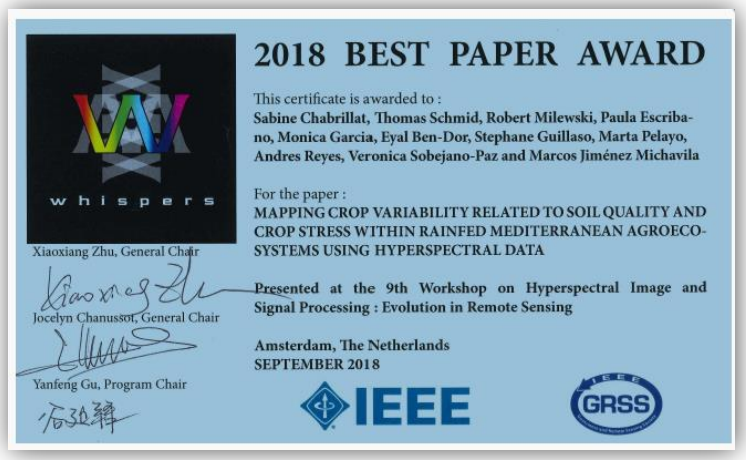





Examples of TNA projects

From 2008-2018 ~50% of all EUFAR flight requests were based on hyperspectral sensors flights

- MASOMED: MApping SOil variability within rainfed MEDiterranean agroecosystems using hyperspectral data
- COOLAPEX: Towards assessment of water quality of the Curonian Lagoon using hyperspectral APEX sensor
- UrbSense: Potential of the combined use of hyperspectral, thermal and LiDAR sensing technologies for characterization of urban green and the built environment
- AHSPECT: Agriculture-Health-SPECTrometry collecting hyperspectral airborne measurements over agro-forestry areas for assessing the agricultural health, physiology and satellite products validation



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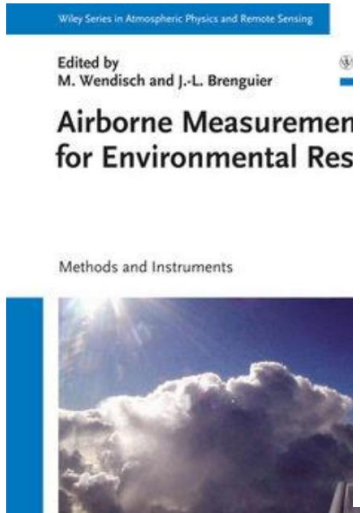


Event name: EUFAR Expert Workshop on Hyperspectral Imaging from UAVs – Applications in Precision Farming

List of documents

Title	Author	Type	Related
Agenda - EUFAR Expert Workshop on Hyperspectral Imaging from UAVs		Meeting agenda	Events: EUFAR Expert Workshop on Hyperspectral Imaging from UAVs – Applications in Precision Farming
Analysing time series of high resolution UAV imaging of agricultural experiments: Results and outlook	BURKART Andreas	Meeting presentation	Events: EUFAR Expert Workshop on Hyperspectral Imaging from UAVs – Applications in Precision Farming
Between plant research and precision farming: UAV related projects at the ETH Zürich Crop Science group	LIEBISCH Frank	Meeting presentation	Events: EUFAR Expert Workshop on Hyperspectral Imaging from UAVs – Applications in Precision Farming
Combining hyperspectral and high spatial image acquisition in a lightweight camera: from COSI-Cam to ButterflEYE LS: Technology & Application	DELALIEUX Stephanie	Meeting presentation	Events: EUFAR Expert Workshop on Hyperspectral Imaging from UAVs – Applications in Precision Farming
Consumer-grade cameras on UAVs for multi-temporal monitoring of vegetation reflectance and NDVI	BERRA Elias	Meeting presentation	Events: EUFAR Expert Workshop on Hyperspectral Imaging from UAVs – Applications in Precision Farming
EUFAR Expert Workshop on Hyperspectral Imaging from UAVs – Information Pack		Meeting preparation	Events: EUFAR Expert Workshop on Hyperspectral Imaging from UAVs – Applications in Precision Farming
Exploring the use of Sentinel-2 and UAV imagery for high resolution crop identification, phenology, and yield estimation	ZABALA Stephania	Meeting presentation	Events: EUFAR Expert Workshop on Hyperspectral Imaging from UAVs – Applications in Precision Farming
Extracting canopy vigor parameters in fruitorchards on multiple scales	VANBRABANT Yasmin	Meeting presentation	Events: EUFAR Expert Workshop on Hyperspectral Imaging from UAVs – Applications in Precision Farming
From research to operationality: a workflow for standardized UAV-borne hyperspectral data	TOMELLERI Enrico	Meeting presentation	Events: EUFAR Expert Workshop on Hyperspectral Imaging from UAVs – Applications in Precision Farming
Hyperspectral remote sensing for precision agriculture applications from airborne and UAS	ROSSINI Micol	Meeting presentation	Events: EUFAR Expert Workshop on Hyperspectral Imaging from UAVs – Applications in Precision Farming
Introduction to EUFAR	REUSEN Ils	Meeting presentation	Events: EUFAR Expert Workshop on Hyperspectral Imaging from UAVs – Applications in Precision Farming
Multi-temporal crop monitoring with spectral snapshot cameras	AASEN Helge	Meeting presentation	Events: EUFAR Expert Workshop on Hyperspectral Imaging from UAVs – Applications in Precision Farming
Participants List - EUFAR EWG on Hyperspectral Imaging from UAVs		Meeting preparation	Events: EUFAR Expert Workshop on Hyperspectral Imaging from UAVs – Applications in Precision Farming
Performance and real time capabilities of the HySpex Mjolnir-1024 hyperspectral camera for end user applications like Precision Farming	KOIRALA Pesal	Meeting presentation	Events: EUFAR Expert Workshop on Hyperspectral Imaging from UAVs – Applications in Precision Farming
Potentials of UAV hyperspectral Rikola sensor for characterizing and monitoring of fluvial environments	DEMARCHI Luca	Meeting presentation	Events: EUFAR Expert Workshop on Hyperspectral Imaging from UAVs – Applications in Precision Farming
Strategies for innovation in a “dynamically reshaping” world: open innovation practices, large industrials, SME/start-up, R&D labs	PAUN Florin	Meeting presentation	Events: EUFAR Expert Workshop on Hyperspectral Imaging from UAVs – Applications in Precision Farming
Yield prediction of potato using hyperspectral and thermal UAV-based data	MAES Wouter	Meeting presentation	Events: EUFAR Expert Workshop on Hyperspectral Imaging from UAVs – Applications in Precision Farming

EUFAR
European Facility for Airborne Research

Presentations:

- Lecture 1: Principles of Field Spectroscopy, and design & calibration of spectrometers for reflectance and fluorescence measurements
- Lecture 2: Field Spectroscopy measurement uncertainties and sampling strategies
- Lecture 3: Airborne hyperspectral imaging spectroscopy - APEX - instrument and its calibration
- Lecture 4: APEX Flight Campaign Planning (scientific and operational)
- Lecture 5: Introduction to UAVs for spectroscopy and remote sensing
- Lecture 6: Regulatory framework of civil use of UVS/ RPAS in Poland and the EU
- Lecture 7: From Radiance to Photosynthesis
- Lecture 8: Theory of Reflectance and Fluorescence, and Approaches to Fluorescence Retrieval from Spectroscopic Measurements
- Lecture 9: Retrieval of vegetation properties in the flux tower footprint from airborne and ground spectral measurements
- Lecture 10a: Introduction to ground measurements of biophysical parameters, chamber and eddy covariance methods for GHG fluxes measurements
- Lecture 10b: Chamber measurements of GHG fluxes
- Lecture 11: Integration of reflectance and fluxes
- Lecture 12: Aspects of Radiative Transfer
- Lecture 13: ESA Earth Observations & Campaigns
- Lecture 14: Atmosperic correction validation for Landsat and forthcoming Sentinel-2 data
- Lecture 15: SPECCHIO
- Lecture 16: Introduction to ecological modelling
- Lecture 17: VITO Central Data Processing



Airborne Imaging Spectroscopy in EUFAR

Joint Research Activities (JRA)

- "HYLIGHT" dealt with the development of methodologies and tools for the integrated use of airborne hyperspectral imaging (HSI) data and airborne laser scanning (ALS) data in order to produce improved HSI and ALS products.
- "HYQUAPRO" developed, implemented and tested quality indicators and quality layers for airborne hyperspectral imagery, and developed higher performing water and soil algorithms as demonstrators for end-to-end processing chains with harmonised quality measures.

HYLIGHT

HYLIGHT TOOLS

>> Combined analyses of ALS and HSI

PML	**ALS/HSI target matching tool :** matches near neighbours of ALS to HSI points and vice-versa
TU Vienna	**opalsRadioCal :** uses Full Waveform information to compute reflectance for laser scanning points of extended targets, enhanced by atmospheric correction
TAU	**LWIR radiance Planck fit and Temperature extraction :** Planck curve fitting with temperature extraction and ALS shadow modelling

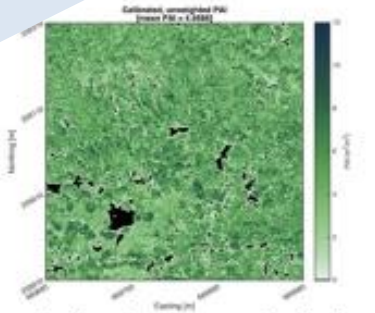
>> HSI to improve ALS

PML, ONERA	**ALS classification tool :** improves classification … classifications. If data are collected at the … cloud & haze
Czech Globe	**BiomassMapper tool :** esti…

>> ALS to improve HSI

INTA	**SLP_ASP** …ation of slope and aspect maps usi… …istics of HSI imagery
VITO	…M from ALS data
	…tmospheric correction of urban HSI images using … 3D information
	…oCorr3D : shadow correction for HSI images using 3D canopy structure parameters derived from ALS and a radiative transfer model
DLR	**LAVA - LAS Variability tool :** calculates error margins of the DSM/ DTM and DSM/ DTM related errors for atmospheric correction steps
UZH	**Irradiance fraction tool :** estimates direct and diffuse irradiance fraction for each HSI pixel using a radiative transfer modelling approach
VITO	**Shadow fraction tool :** shadow fraction with LAS processing and put in the same grid cell
UZH	**PAI estimation tool :** estimates voxel based plant area index (PAI) for the parameterisation of the radiative transfer model DART
VITO	**Tree species classification tool :** classifies tree species using ALS-derived vegetation percentage height values (PHV) as additional layer

…t of the PAI tool for the …redits UZH)

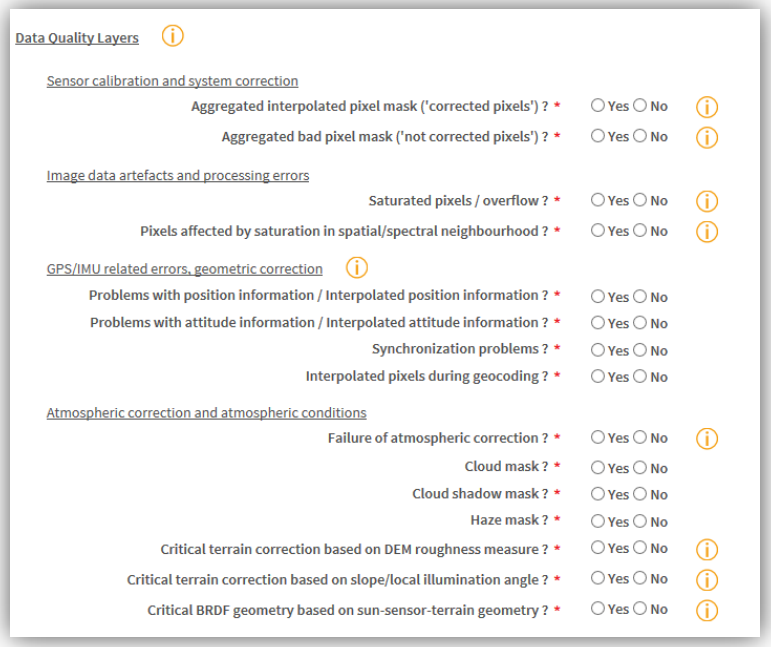


Extraction of PAI allows the parameterisation of the DART model for the analysis of the 3D radiative budget to quantify the amount of irradiance for each HSI pixel to be used to compensate shadowed pixels

HYLIGHT working group photo

For more information, contact lls.Reusen@vito.be or visit www.eufar.net/tools

HYQUAPRO



Data Quality Layers

Sensor calibration and system correction

Aggregated interpolated pixel mask ('corrected pixels') ? *	Yes No
Aggregated bad pixel mask ('not corrected pixels') ? *	Yes No

Image data artefacts and processing errors

Saturated pixels / overflow ? *	Yes No
Pixels affected by saturation in spatial/spectral neighbourhood ? *	Yes No

GPS/IMU related errors, geometric correction

Problems with position information / Interpolated position information ? *	Yes No
Problems with attitude information / Interpolated attitude information ? *	Yes No
Synchronization problems ? *	Yes No
Interpolated pixels during geocoding ? *	Yes No

Atmospheric correction and atmospheric conditions

Failure of atmospheric correction ? *	Yes No
Cloud mask ? *	Yes No
Cloud shadow mask ? *	Yes No
Haze mask ? *	Yes No
Critical terrain correction based on DEM roughness measure ? *	Yes No
Critical terrain correction based on slope/local illumination angle ? *	Yes No
Critical BRDF geometry based on sun-sensor-terrain geometry ? *	Yes No

- Common data descriptors and quality layers for hyperspectral image data
  → implemented in EUFAR's Metadata Creator (EMC)
- HYSOMA (Hyperspectral SOil MApper) by GFZ
  → software for soil mapping applications of hyperspectral imagery
- Inherent optical property model by PML
  → water quality algorithms

EUFAR
European Facility for Airborne Research

ICARE
International Conference on Airborne Research for the Environment

- ICARE 2010 conference
  "10 years of EUFAR"

- ICARE 2017 conference
  "Developing the infrastructure to meet future scientific challenges"

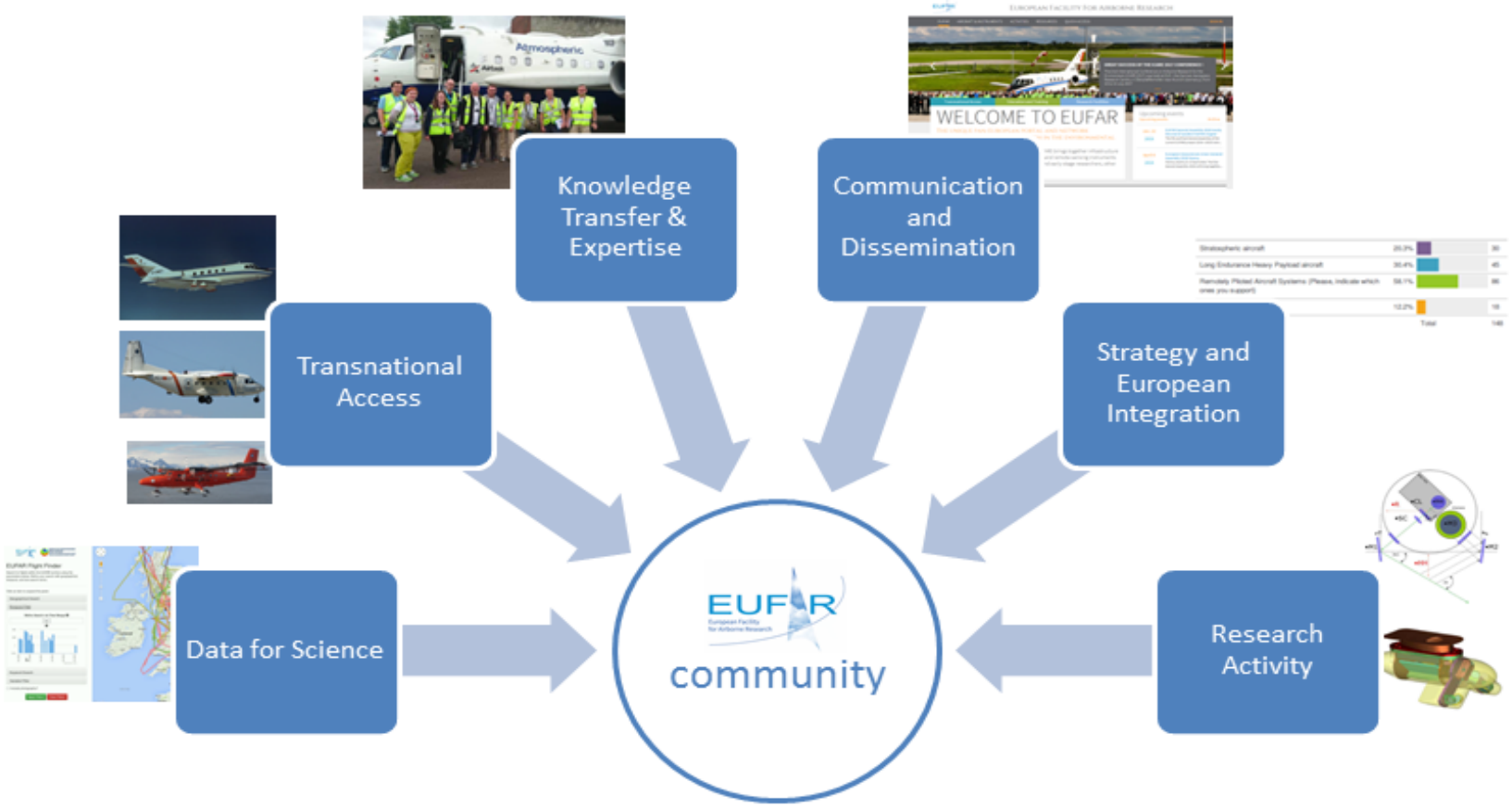
EUFAR AISBL

→ International non-profit association (**A**ssociation **i**nternationale **s**ans **b**ut **l**ucratif)
Formed in Jan 2018 by core group of member organisations

Objectives

- Assure the continuity of EUFAR
- Coordinate the distributed existing infrastructures
  - NOT centralise the infrastructures
- Consolidate the network of airborne research infrastructures
  - NOT acquire & operate a new infrastructure
- Forum for discussion of future platform requirements
- Implement and manage a scheme of Open Access
- Pursue European research infrastructure integration
- Broaden the airborne research community to access additional financial resources

EUFAR AISBL



Any organization with an interest in airborne research is welcome to join EUFAR AISBL.

Remark: CNR and Tel-Aviv University will be official members soon

EUFAR website

www.eufar.net

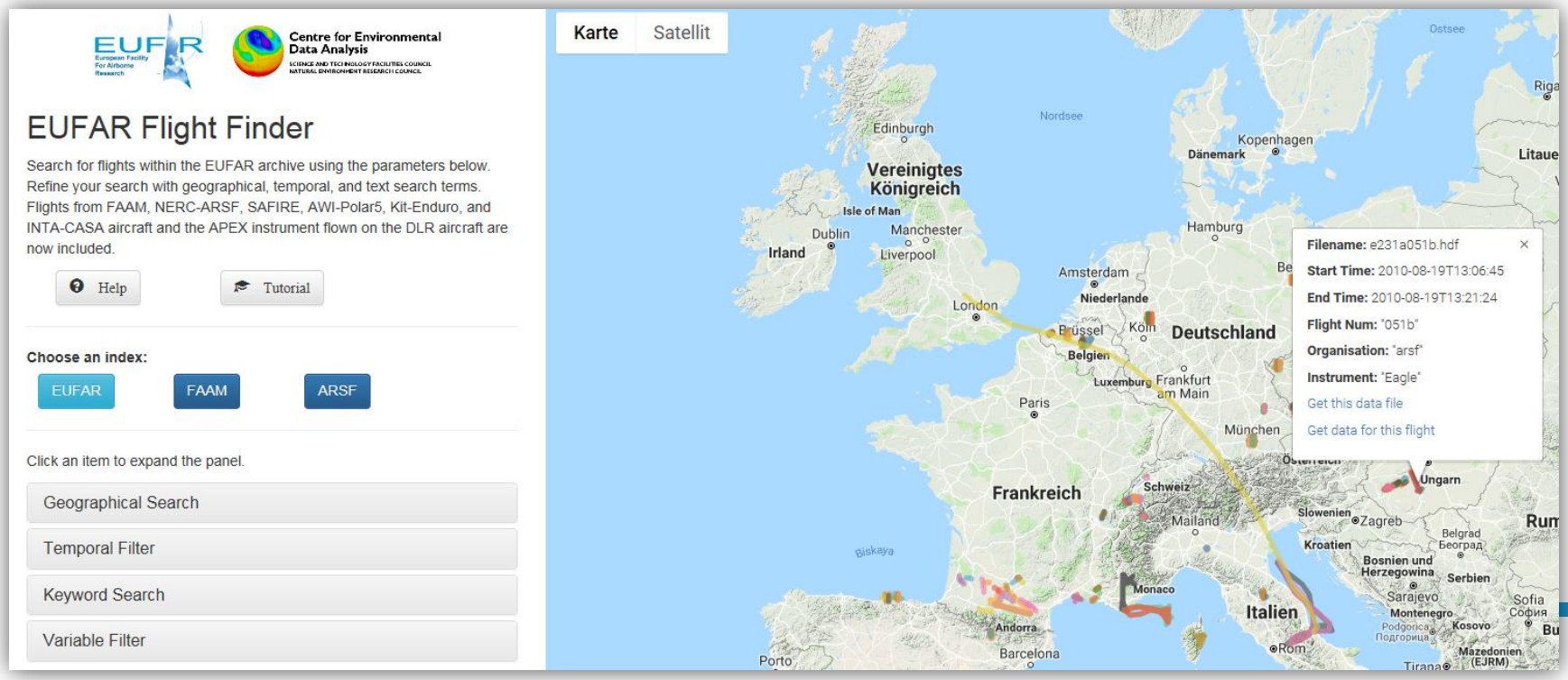
→ central information portal

- Information
- Documentation
- Data
- Application forms
- News / articles
- Events / registration

EUFAR data

www.eufar.net/data-archives/ or

http://data.ceda.ac.uk/badc/eufar/data/



Current focus of EUFAR

- Open access scheme
  - Open Access should provide users with the opportunity to participate in the planning and prioritization of airborne campaigns in addition to data access
- Apply for EU funding to
  - support the mobility of personnel in the framework of Open Access (ERI or MSCA)
  - cover activities external to the self-financing perimeter of the structure (TA, ET, JRAs, specific core developments)

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